SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

FACULTY OF CHEMICAL AND FOOD TECHNOLOGY

INSTITUTE OF INFORMATION ENGINEERING, AUTOMATION AND MATHEMATICS

Theory of Automatic Control 3

Model Predictive Control

Bc. Denisa Chowaniecová 11/2021

1 Specification

The given controlled process is stable, second order transfer function

$$G(s) = \frac{Z}{T^2s^2 + 2Ts + 1}$$

where gain is $Z = 1.5$ and time constant is $T = 1$. To design MPC (model predictive controller) we have to transfer our continuous time process to discrete time state space with sampling time $T_s = 0.3$. The obtained controlled system is in the following form:

$$\begin{aligned} x(k+1) &= Ax(k) + Bu(k) \\ y(k) &= Cx(k). \end{aligned}$$

We have also given the initial conditions $x_0 = [0; 0]$ and the input contraints $-1 \leq u(k) \leq 1$. The MPC controller parameters are Q, R and N and the reference, that we want to reach by regulation, is $r = 1$.

2 Simulation of the MPC setups

The initial setup of the controller parameters was given as $Q = 10, R = 1$ and $N = 10$. As we can see in the figure 1, with this setup we didn't reach our setpoint. The control performance of the each controller is described by the following three control criteria:

$$ISE = \int_0^{t_{sim}} e(t)^2 dt \quad , \quad ISU = \int_0^{t_{sim}} u(t)^2 dt \quad , \quad \sigma = \frac{y_{max} - y_\infty}{y_\infty - y_0}$$

where $e(t)$ is regulation error, $u(t)$ is input of the system and σ is maximal overshoot.

The second setup was with goal to decrease offset compared to first setup. To achieve these goal, we had to increase Q parameter and decrease R parameter (figure 2).

The third aim was to decrease ISU compared to first setup. This goal was obtained with larger parameters R and N (figure 3).

The last aim was to decrease maximal overshoot compared to first setup. In the first case, we didn't have any overshoot, so we tried to find values of parameters, that will give the setpoint and the smallest overshoot. All tuning parameter values and control performance criteria of the individual MPC setups are written in the following table 1.

	N	**Q**	**R**	**ISU**	**ISE**	**σ (overshoot)**
Initial Setup	10	10	1	5.827	1.035	–
Decreased Offset	10	100	0.1	6.330	1.018	0.0044
Decreased ISU	50	10	2	5,335	1.094	–
Decreased σ	10	150	0.1	6.333	1.018	0.0038

Table 1: Table of MPC setups

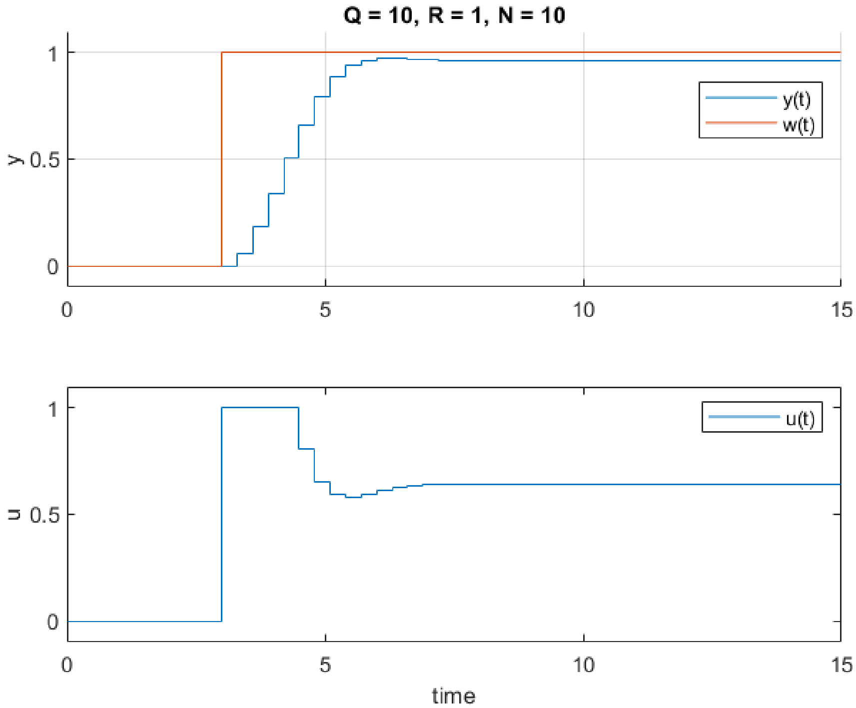

Figure 1: Output and input of the system for initial setup.

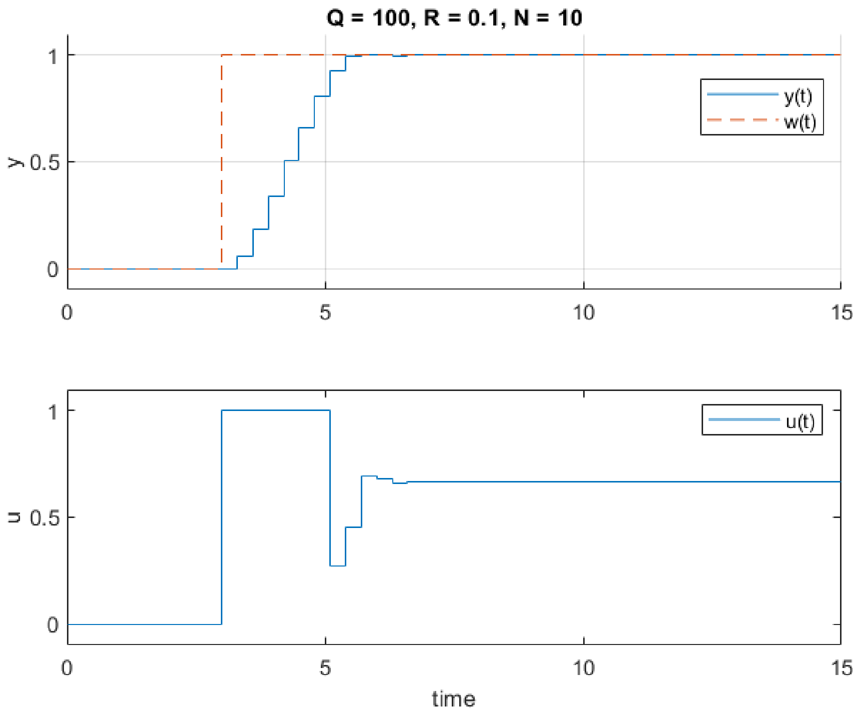

Figure 2: Output and input of the system for decreased offset.

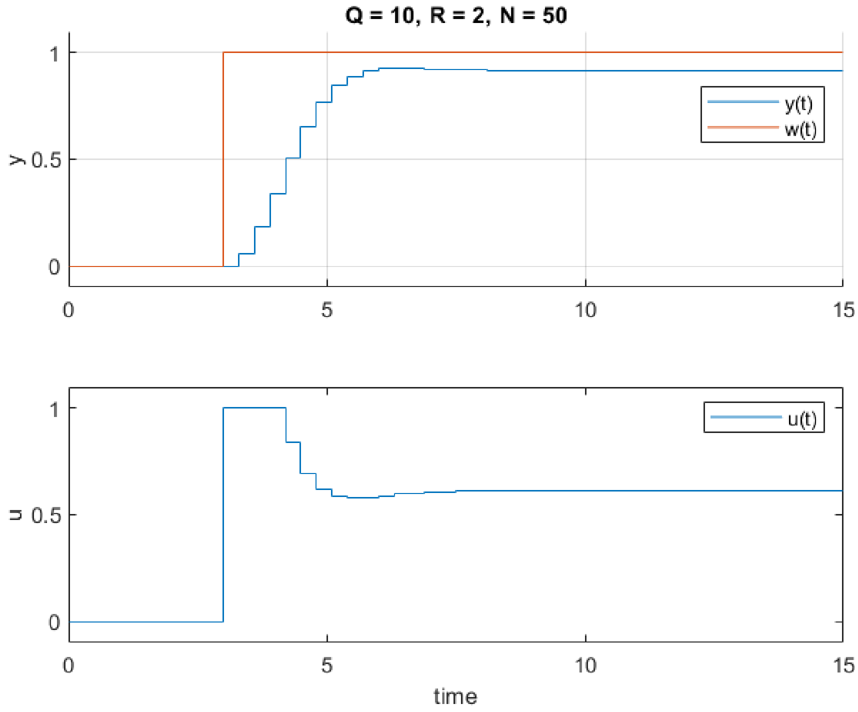

Figure 3: Output and input of the system for decreased ISU.

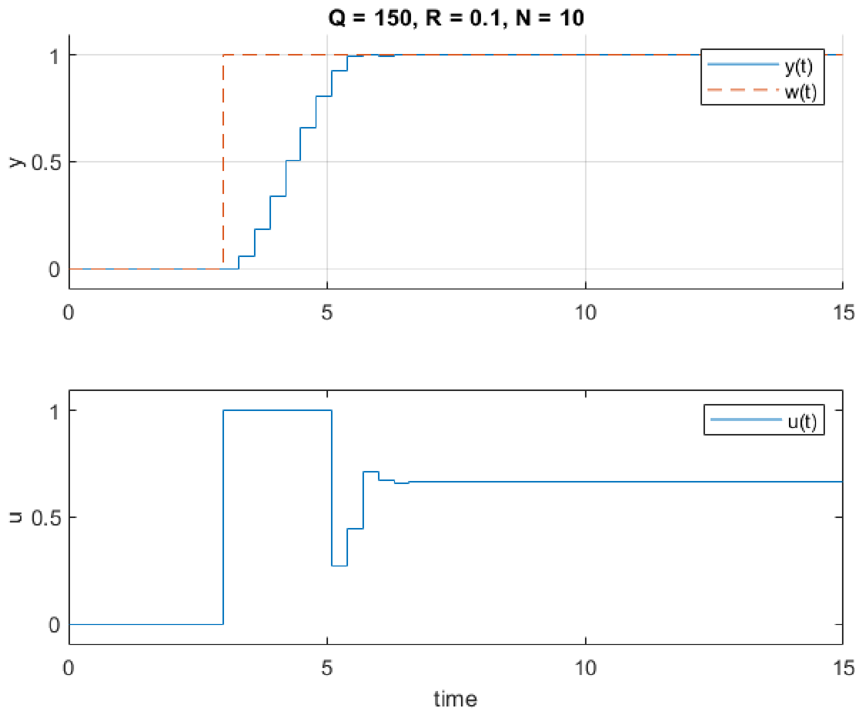

Figure 4: Output and input of the system for decreased maximal overshoot σ.

3 Conclusion

The aim of this assignment was to design the model predictive controller (MPC) for a given MIMO (multiple input, multiple output) system, by different setups of the controller parameters Q, R and N. Based on our results we can conclude, that the increased Q parameter affects the speed and aggressiveness of the system. On the other side, the increased value of the R parameter affects less aggressive on the system. The N parameter determines how many forward steps the controller predicts. With the higher value of N we get the lower value of the ISU.